AYK Region
Herring Report #9

Briefing Report on the Fishery Management Plan for Herring in the Eastern Bering Sea

Submitted to the North Pacific Fisheries Management Council by the Management Plan Development Team as:
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INTRODUCTION

This report describes the important features of the eastern Bering Sea herring fishery management plan being developed for the North Pacific Fisheries Management Council (NPFMC). Included is a discussion of the status of the resource and fisheries, present management program and considerations for future management measures. The timetable for plan completion requires submission of the final draft to the NPFMC by March of 1979 in order to allow plan implementation by the early spring of 1980.

Herring populations have declined over the past two decades and at present most major world fisheries are closed or support reduced harvests (Figure 1). The primary cause of declines is believed to have been overfishing. Recruitment failure or environmental changes were also suspected as secondary causes of failure for some stocks. Most stocks in the northeastern Pacific on the other hand are in relatively good condition.

A domestic fishery has developed recently in the eastern Bering Sea in response to favorable market conditions and prices created by the worldwide herring shortage. Additional stimulus has been provided through incentives given U.S. fishermen under the Fisheries Conservation and Management Act of 1976 (PL94-265). Barring major changes in resource status or market conditions, expansion of the domestic fishery should continue resulting in the elimination of the foreign fishery except for incidental harvests. Estimated ex-vessel and wholesale values of the 1978 domestic fishery exceeded $2.5 and $12.0 million respectively. These values are expected to increase during the next few years.

Herring demonstrate extreme fluctuations in year-class recruitment due to variable spawning success and a high rate of natural mortality. These fluctuations effect the availability of herring to the fishery and necessitate a close monitoring of the resource and the fisheries in order to minimize the likelihood of stock failure. To provide effective management of eastern Bering Sea herring stocks within the framework of existing socio-economic conditions, plans must be formulated which take into account the biological factors inherent in herring populations and those unique to the Bering Sea. The development of a sound management scheme is complicated by a lack of understanding of specific fish stocks and the pressing need to give equitable consideration to the full spectrum of demands placed on the resource by all user groups.

LIFE HISTORY

Timing and Distribution

Soviet research has determined that separate wintering areas exist for eastern and western Bering Sea herring stocks (Figure 2). The eastern stock winters in an area northwest of the Pribilof Islands. Herring depart the Pribilof area during late March and migrate northeast and southeast toward the Alaska coast for spawning. These herring are believed to spawn from Norton Sound south to the Alaska Peninsula. Spawning observations made in Norton Sound and Kotzebue Sound, along with Soviet distributional studies, suggest that more northern stocks

may exist and utilize a different wintering area.

Most spawning herring appear near the western Alaska coast immediately following ice breakup in mid-May and early June. Spawning begins in mid to late May in Bristol Bay and along the Alaska Peninsula and progresses in a northerly direction along the coastline until late July and August in portions of the Seward Peninsula and in the Chukchi Sea (Figure 3). Both pre and post spawning herring populations remain in the nearshore waters throughout the spring and summer months.

Spawning

Two basic spawning habitat types have been identified along the Bering Sea coast: exposed rocky headlands and shallow lagoons, inlets and bays. The first type characterizes spawning areas from Norton Sound to Bristol Bay. In these areas spawning occurs in intertidal and shallow subtidal water with spawn being deposited primarily on the rockweed kelp (Fucus furcatus).

Most spawning on the Seward Peninsula occurs in shallow lagoons and bays where eelgrass (Zosteria sp.) is common. The bottom type is usually sand and/or mud and spawning usually occurs in shallow subtidal water less than two meters deep.

Herring eggs are adhesive and may be deposited in several layers. Herring hatch as larvae after about 10-21 days depending upon water temperature and following a larval stage lasting approximately 6-10 weeks they begin to metamorphose into juveniles. Little is known about the juvenile stage from the time they leave the coast in their first summer until they attain sexual maturity and are recruited to the adult population. Herring begin to mature at age 2 while the majority reach maturity at age 3 and 4.

Stock Units

Aerial surveys conducted in the Bering Sea from 1976-1978 indicate herring abundance, based on school surface area estimates, is greatest south of the Yukon River with the largest concentrations observed in the Togiak district of Bristol Bay (Figure 4).

Several spawning stock units occur along the coast although the precise number of and relationship between individual units is not fully known.

Results of electrophoretic analysis show some significant differences between herring in the Bering Sea and Gulf of Alaska. Preliminary results on samples collected from two separate coastal areas in the Bering Sea in 1978 also show significant differences.

Differences in growth rate and mean size-at-age may also be useful in identification of stocks. After ages 3-4 for instance, growth of older fish in the Bering Sea is faster than stocks in the Gulf of Alaska

and British Columbia. Bering Sea herring also attain a larger maximum size than more southerly stocks. In general, mean size-at-age increases in a northerly direction along the North American coastline from San Diego to Bristol Bay and the Yukon-Kuskokwim River Delta. Mean size-at-age then decreases from there northward toward Bering Strait and the Chukchi Sea. These size differences among spawning herring populations in the eastern Bering Sea may be suggestive of the occurrence of different stock units (Figure 5).

DOMESTIC SUBSISTENCE FISHERY

Herring is a traditional subsistence food item of numerous Bering Sea coastal residents. Most subsistence fishing takes place on spring spawning runs although a number of fishermen from Golovin Bay northward to Kotzebue utilize herring to a limited extent from a fall run. Most harvests are made with gillnets although some beach seining is done in Norton and Kotzebue Sounds.

Villages south of the Yukon River are generally more dependent upon the subsistence fishery for herring than villages to the north. This is believed to be due to the availability of alternative food sources and lower abundance of herring north of the Yukon River. Subsistence utilization of herring is greatest in the villages between the Kuskokwim and Yukon Rivers and predominantly in the vicinity of Nelson Island (Figure 6). Surveys conducted since 1975 indicate a total annual subsistence harvest of approximately 100 metric tons (m.t.) is made in the Bering Sea.

Subsistence utilization of herring by coastal residents north of the Yukon River and south of the Kuskokwim River is relatively insignificant. A more comprehensive review of this fishery is included in a September, 1978, Dames and Moore report on "The Social and Economic Impacts of a Commercial Herring Fishery on the Coastal Villages of the Arctic/Yukon/Kuskokwim Area."

DOMESTIC COMMERCIAL FISHERY

Sac Roe Fishery

The first domestic commercial herring sac roe fishery in Bristol Bay occurred in 1967 when a single operator purchased 122 m.t. of fish. These first catches were taken with gill nets exclusively and this type of gear has been used successfully each year that the fishery has operated. During the eleven year history of this fishery, purse seines have also been employed and since they were first introduced in 1968 have taken an average of 70% of the catch. No herring harvests were reported in Bristol Bay in 1971 and 1976. Annual catches during other years remained small until 1977 and 1978 when the number of operators and amount of fishing effort increased dramatically and resulted in record catches of 2,536 and 7,033 m.t. respectively (Table 1 and Figure 7).

Commercial harvests of herring for sac roe have also been reported from Norton Sound with an initial harvest of 18 m.t. in 1964. No fishery

developed in 1965-68 or in 1975 and this fishery has generally remained at a relatively low level throughout its history.

During 1978 a total of 16 operators purchased 7,033 m.t. of herring in Bristol Bay. Over 80% of the harvest was taken from the Nunavachak section with lesser amounts coming from the remainder of the Togiak district. Ninety-one percent of the catch was taken by 25 units of purse seine gear making 237 deliveries while the balance was taken with 40 units of gill net gear making 249 deliveries. The peak daily harvest occurred on May 24 when 1,633 m.t. were delivered. Most of the herring taken this past season were primary processed on the fishing grounds and subsequently transferred aboard eleven foreign vessels anchored in a designated constructive port within Kulukak Bay.

The mean roe recovery in Bristol Bay was 8.2% and, although there was a wide range of prices paid for the fish, an average of $300 per short ton put the ex-vessel value of the sac roe fishery at $2.3 million.

Three companies that operated in Bristol Bay in 1978 also traveled north to the Security Cove area and took approximately 259 m.t. before the fishery was closed by emergency order. A catch of 13 m.t. was also made in Norton Sound this season.

All of the processors who participated in 1978 have indicated they plan to return next season with expanded and improved operations while many new companies have also expressed their interest. Preliminary estimates indicate that the capacity of the sac roe fleet in 1979 will exceed that of the past season and could range from 11-23,000 m.t. Several processors have expressed interest in extending their future efforts north of the Togiak district but due to possible similarities in run timing, the distances involved and the smaller harvest guidelines, a major northward shift in effort is not anticipated. Local residents are currently seeking markets and special training to develop the necessary fishing skills and equipment preliminary to entering the Security Cove-Goodnews Bay fishery in 1979.

Roe-on-kelp-fishery

The commercial herring roe-on-kelp fishery originated in Bristol Bay in 1968 and has operated annually since that time. For the first six seasons one processor was involved and only limited harvests resulted. Since 1974 there has been a steady increase in effort and production culminating in a doubling of the number of buyers from 5 to 11 and a record harvest of 150 m.t. in 1978 (Table 1 and Figure 8). The product being harvested is almost exclusively rockweed kelp and although Ribbon Kelp (Laminaria sp.) is present, it doesn't appear to be an important substrate.

Herring-roe-on-kelp was first harvested commercially in Norton Sound in 1977 when less than one metric ton was reported. A small harvest of three metric tons was taken in Norton Sound in 1978 but processors indicated more kelp could have been taken if spawning hadn't occurred in such deep water.

The record roe-on-kelp harvest in Bristol Bay in 1978 was taken by 160 different individual fishermen in 349 deliveries. Eleven different processors participated and paid approximately $120,000 to fishermen for the combined harvest.

The prospects for the roe-on-kelp fishery in Bristol Bay indicate continued expansion in effort and processing capacity but the market for rockweed kelp may be a limiting factor. The effect of the harvest on the kelp flora will also require close monitoring as the fishery develops.

FOREIGN FISHERY

Foreign fishing of eastern Bering Sea stocks began in 1960 when Soviet exploratory trawlers located the herring winter grounds northwest of the Pribilof Islands (Figure 2). Herring were abundant and the Soviet fleet increased annually until 1964-65 when 100-150 vessels fished. With the exception of the 1965-66 season when the unavailability of herring concentrations reduced effort to 15 trawlers, Soviet effort continued to increase into the early 1970's. This was followed by a decline as herring abundance decreased and by 1975-76 most of the effort was directed to pollock and very little to herring.

The Japanese joined the Soviets in trawling for herring in the eastern Bering Sea in 1966 and began a gillnet fishery east of 175°W in 1967. The Japanese and Soviet trawl fisheries concentrated their effort from November to April inside the 200-meter contour between the Pribilof Islands and St. Matthew Island. The Japanese gillnet fishery operated from April to June from Bristol Bay to Norton Sound until 1977 when coastal waters east of 168°W and north of 58°N were closed to protect coastal subsistence fisheries. In 1977, a limited amount of gillnetting occurred outside the closed area, but none in 1978 as the closure line was extended to include all waters east of 168°W.

The overall foreign catch trend since 1967, when official USSR data became available, shows that peak production occurred in 1968-69 with a harvest of 128,185 m.t. (Table 2 and Figure 9). Since 1968-69 production has steadily declined, and although the catch increased in 1976-77 to approximately 20,000 m.t., this was still only 17% of the 1968-69 peak.

Soviet harvests peaked at 92,228 m.t. in 1969-70, but since then have generally declined with 9,518 m.t. and 18,907 mt reported for 1975-76 and 1976-77, respectively. Japanese trawl catches have generally paralleled Soviet trends. Japanese trawl catches were extremely low in 1972-74 but rose to an average of about 3,000 m.t. in subsequent years. Gillnet catches show no sustained trend but appear lower in years of heavy pack ice.

Under provisions of extended jurisdiction U.S. observers are placed on foreign vessels fishing in the U.S. fishery conservation zone. In the eastern Bering Sea 33 observers were aboard vessels through June of the 1977-78 season. Data obtained revealed that significant amounts of herring are taken incidentally in hauls made for other species, primarily pollock. Although the analysis of herring catch rates from observer data is limited by the lack of observer coverage, observer reports

reveal that the majority of herring harvested by Japan and the USSR are taken by large factory trawlers. The highest rates and amounts occur during the winter months (November-March) when herring are concentrated northwest of the Pribilof Islands. In other areas and for other vessel classes, the incidence of catch is small or is attributable to target fishing on herring.

Herring catches as a percent of total catch were much lower in the Japanese fisheries than in the Soviet fisheries in statistical Area II (170°W-180°W north of 55°N). The lower rates of Japanese catches in this area are substantiated by observer reports which indicate that Japanese vessels were attempting to avoid areas with herring concentrations so as not to exceed their quota and lose their larger fisheries. The observed differences may also be due to differences in fishing methods since the Japanese vessels fish their nets on the bottom while the Soviets fish off the bottom.

STOCK STATUS

At present the status of herring stocks in the eastern Bering Sea is not fully known. The catch and CPUE of Japanese trawlers had been the primary indicator of herring abundance but are no longer useful as trawl catches are now largely incidental to other fisheries. This is the result of a combination of factors including decreased herring abundance, an increase in pollock abundance, and the low total allowable catches of herring in recent years.

The Japanese stern trawler data revealed that both catch and CPUE dropped from the peak years in the late 1960's (Figure 10). CPUE for the Japanese eastern Bering Sea gillnet fishery does not reveal any consistent downward trend. This may be due to ice conditions and the gillnet fishery targeting on spawning concentrations which may not reflect abundance of the total population.

Coastal residents, primarily subsistence fishermen from the area north of Cape Newenham, have indicated that herring abundance has declined from previous levels. The domestic commercial fishery has not existed long enough at levels high enough for trends to be discernible. The only time series data available from the domestic fishery are limited age frequency and aerial survey data.

Aerial surveys are not always able to identify the species of fish and can't fully quantify the biomass of the schools seen, but observations have revealed an increasing trend in herring abundance in most nearshore areas, during the last two seasons. The only comparable aerial survey data over several years exists for southern Norton Sound which indicates that the recent increased abundance is still considerably less than that recorded during the late 1960's and early 1970's.

Some herring age and length-frequency data are avilable from the Japanese and Soviet fisheries from the early 1960's to the present.

These data and age data collected by Alaska Department of Fish and Game show that the herring harvests of the 1960's-early 1970's were made on older and larger herring than in more recent years (Figure 11).

Research catches from Bristol Bay in 1976 indicated that the 1972 year class was much stronger than previous year classes. In 1977 the 1972 year class continued strong in the fishery, comprising approximately 40% of the catch. The 1973 year class also was a major part of the fishery, accounting for approximately 50% of the 1977 Bristol Bay catch. Recruitment appeared to have continued strong in 1978 with age 4 fish comprising 65% of the purse seine fishery.

All of the available data indicates that eastern Bering Sea herring stocks declined in abundance in the early 1970's. This decline was evidently due to a combination of overfishing and the occurrence of a series of weak year classes. The age frequency and length frequency data indicate that recruitment to the fishery was very low in the late 1960's and early 1970's but appears to have increased as evidenced by the relatively strong recruitment of the 1972, 1973 and 1974 year classes at age 4. Due to the limitations of available data, it is difficult to arrive at a quantitative description of the recent apparent increases in herring abundance.

Two estimates of total eastern Bering Sea herring biomass include one at 2.16 million m.t. based on Soviet hydroacoustic surveys in 1963 and a second estimate of 2.7 million m.t. based on computer simulations of the annual average herring biomass required to maintain the present composition of the ecosystem.

Estimates of herring yields using the MSY concept are difficult to apply to herring because of the potential for rapid changes in abundance. Models used to estimate MSY assume a static age structure and stable recruitment rates. The basic premises of these models are that stocks are in equilibrium and surplus production exists which can be harvested without effecting the productivity of the stock.

One approximation which incorporates estimates of rates of natural mortality along with unexploited biomass provide an MSY of 508,000 m.t. Another method using a general production model and the reported catches and surveillance estimates of boat days estimated MSY to be 594,000-654,000 m.t.

Equilibrium yield (EY) is a much more meaningful concept for herring since it is based on the best estimate of the current condition of stocks. It is the harvest that will maintain a stock at approximately the same level over a period of time and set of prevailing environmental and ecological conditions and is the maximum production that is sustainable under current population conditions.

Herring EY is much lower than the estimated MSY because of the nature of mortality rates and the age distribution of biomass. Herring in the eastern Bering Sea fully recruit at age 4. By age four it is

estimated that only about 30% of a year class's biomass remains in the ecosystem (Figures 12 and 13). At biomass levels of 2.16-2.70 million m.t. the maximum exploitable biomass (herring of age 4 or greater) is estimated to be 650-810,000 m.t.

Several procedures have been proposed for estimating EY for herring. These estimates range from a low of 20% of the exploitable biomass (to help guard against extremely low recruitment) to a high of 39% (which would be only slightly below MSY and is based on yield percent analysis). Applying these methods to eastern Bering Sea stocks the EY estimate would range from 130-316,000 m.t.

A comparison of catch and catch per unit effort from 1967 to 1975 reveals that this range of harvest rates was not sustainable. This could be due to a rapid change in equilibrium conditions (very low recruitment levels) or that the biomass estimates on which EY is based are too high. The average catch for the period 1967-75 was 26% of the estimated EY at a 30% exploitation rate. Using this percentage difference, estimated exploitable biomass decreases to 169-211,000 m.t. and estimates of EY a corresponding percentage. At these biomass levels estimate EY would range from 34 to 82 thousand metric tons at the two extremes of exploitation rates.

Since recent estimates of biomass are unavailable, it is difficult to arrive at a precise estimate of EY. Reliable biomass estimates can only be developed through either surveys or through virtual population analysis in which biomass is estimated from age specific catches.

Until biomass estimates can be obtained, management must be based on the available trend data. Since these data are imprecise and stocks are still evidently down from former levels of abundance, harvest levels should be set near the recent five year average of 23,000 m.t. to insure that adequate spawning stocks are maintained or developed.

MANAGEMENT MEASURES

Introduction

To permit the development of a domestic commercial fishery while meeting the needs of an existing subsistence fishery, a coordinated management plan must be developed that will encourage full utilization of the resource yet at the same time maintain and enhance the condition of the affected stocks of herring. A conservative approach to management of the commercial fishery is dictated in recognition of the present inadequate data base and the need to provide for legitimate subsistence uses. Management measures must be implemented to avoid overfishing on stocks or year classes of low abundance so as not to further impair recruitment. A major advantage to the expansion of the domestic fishery, besides the obvious economic benefits to U.S. fishermen and industry, is that it is displacing an offshore foreign fishery that intercepts a mixture of, stocks of varying abundance and productivity. The single stock management approach inherent in management of nearshore fisheries affords protection and regulatory rehabilitation of weak stocks and

optimum harvesting of strong stocks.

A better understanding of the origin, distribution, movement pattern, age structure and fluctuating abundance of herring must be obtained in order to more accurately define yield and implement a more meaningful management program. Some of these needs are being partially met through current studies by the Department of Fish and Game and National Marine Fisheries Service which have been previously reported to the Council in detail.

Existing policies, laws and regulations

Domestic fishery: A provisional policy issued by the Department of Fish and Game states in part that 1) increases in herring harvest levels must be consistent with biological productivity and increased stock assessment capability; and 2) every effort will be made to foster the fullest utilization of herring at the local level consistent with economic viability of the industry and state regulations governing food sanitation. Recently enacted state laws that affect the herring fishery include the prohibition against the waste of carcasses from commercially taken herring and the establishment of subsistence use as the priority use of Alaska's fish and game resources.

Important fishing regulations promulgated in 1978 by the Alaska Board of Fisheries include the following:

1. Open and closed waters: Boundaries of most commercial fishing districts have been established adjacent to major spawning areas to minimize interception of stocks bound for other areas (Figure 14). The large closed area in the Yukon-Kuskokwim River Delta is for the purpose of protecting an important subsistence fishery in that area. Other areas (e.g. Hooper Bay, Scammon Bay, etc.) are closed to avoid gear conflicts where subsistence fishing occurs.

2. Guideline harvest levels: Relatively small guideline harvest levels are in affect for each fishing district and are based on conservative estimates of sustained yield. Harvests in each of these districts (or sections) can be increased or decreased depending on the abundance of herring as determined during the season. Combined guideline harvests in 1978 totalled 7700 mt including 6000 m.t. for the Togiak district and 1700 m.t. for districts located north of Bristol Bay. The regulations also permit herring fishing along the Alaska Peninsula but due to the absence of any recent history of commercial fishing no guideline harvests were designated for this area.

3. Gear: Purse seines and gillnet can be operated except that beach seines can also be operated north of Bristol Bay. Only gillnets can be operated in the Goodnews Bay subdistrict.

4. Gear restrictions: Limits are imposed on the length and depth of purse seines (150 fathoms, 850 meshes) the length of gillnets (50 fathoms per net and not more than 150 fathom in use by an individual) and a three inch maximum gillnet mesh size for districts north of Bristol Bay to minimize the incidental capture of salmon.

5. Primary processing: An emergency regulation promulgated by the Board of Fisheries was in affect during the 1978 spring sac roe fishery. This regulation prohibited foreign vessels and aliens from catching, tendering unprocessed fish and processing fish within the internal waters and territorial sea of the State.

6. Subsistence fishing regulations: There are no restrictions on subsistence fishing in respect to harvest levels, seasons, areas, gear or gear specifications.

Foreign Fishery: Major federal laws and regulations affecting foreign herring fishing in the central and eastern Bering Sea include:

1. No foreign vessels may fish within twelve miles of the baseline used to measure the Territorial Sea except in portions of the western Aleutian Islands.

2. No foreign vessels may fish for herring east of 168° W. longitude. This was adopted to prevent overexploitation of stocks important to U.S. coastal residents from Bristol Bay to Norton Sound and virtually eliminated the Japanese gillnet fishery.

3. No trawling year-round by foreign vessels in the Bristol Bay "Pot Sanctuary" area and during specific times in other areas in the southeastern Bering Sea. These closures, designed to protect juvenile halibut and U.S. crab pots, afford some protection to herring stocks as well.

4. In 1977, an equilibrium yield (EY) of 21,000 m.t. was established in the Preliminary Fishery Management Plan. Of this total 20,000 m.t. was allocated to the foreign fishery based on a projected domestic harvest (commercial and subsistence) of only 1000 m.t. Due to a unanticipated commercial fishery in Bristol Bay, the EY was exceeded by approximately 2300 m.t. in 1977. An adjusted EY of 18,670 was then calculated for 1978 by subtracting the 1977 overage. A total of 8670 m.t. was allocated to foreign fisheries in 1978 based on a projected domestic harvest of 10,000 m.t.

Future Management Considerations

The major emphasis of this section relates to the management of fisheries outside the territorial sea. However, it should be noted that the present domestic fishery is located within the territorial sea and is under the jurisdiction of the State of Alaska. The Alaska Board of Fisheries during its December 1978 meeting will consider and act upon thirty proposals submitted by the public and the staff of the Department of Fish and Game dealing with changes in the 1979 commercial herring fishing regulations for the Bering Sea. These proposals cover a wide range of regulatory options including changes in guideline harvest levels, fishing district boundaries and gear-vessel specifications in addition to establishing control of offshore domestic fishing through a landing law. It is essential that the Alaska Board of Fisheries and

North Pacific Fisheries Management Council closely coordinate their activities to facilitate development of compatible regulations.

A major element in the management of present and future fisheries in offshore Bering Sea waters is the indiscriminate harvesting of herring from several mixed stocks that spawn along the coast of western Alaska. A deleterious affect of offshore fishing is the possible overharvesting and decline of smaller stocks which may be important to U.S. commercial and subsistence fishermen in coastal areas. In general, it is recommended that the interception of mixed stocks be minimized until the origin and distribution of these stocks be determined throughout their range. Until this information can be obtained, the major fishing effort should be conducted in coastal waters where the stocks are separated to the greatest extent as in the case with the present domestic sac roe fishery.

Limited harvesting of herring in offshore waters cannot be prohibited due to the unavoidable by-catch resulting from fisheries targeting on other species. Measures may have to be implemented in the future to insure that fisheries target on species other than herring and to control the herring by-catch of fisheries targeting on species considerably more abundant than herring. Methods of control may include quotas, area, time restrictions, gear restrictions or a percentage of the herring by-catch in the total catch based on past fishery performance (Figure 15).

Development of large-scale domestic offshore fisheries to supply bait or food markets should be delayed until 1) origin of stocks can reasonably be determined; 2) viable methods of assessing stock condition and managing the presently expanding sac roe fishery are developed; and 3) a comprehensive management plan is developed for each stock taking into consideration the needs of all user groups. However, it may be desirable to allow limited domestic fisheries in offshore waters under the following conditions: 1) to optimize harvests for sac roe markets if weather and other conditions not related to herring abundance act to limit harvesting; 2) to supply bait or food markets. The interception of mixed stocks by such fisheries should be minimized by restricting effort to areas located immediately adjacent to presently described fishing districts and the adoption of quotas and/or area-time restrictions.

Another important element involves methodology to determine the allocation of harvests between domestic and foreign fisheries. Current methods for calculating TALFF involves deducting the expected domestic annual harvest from the optimum yield without providing for a "harvest reserve". In order to maintain optimum yield during the short term, any harvest overages that occur during the current calendar year will be subtracted from TALFF during the next calendar year.

The "harvest reserve" method involves the reservation of a small percentage of the total harvest for allocation to either the domestic or foreign fishery later in the year. For example, 10% of the optimum yield could be reserved for later allocation based on current year fishery performance that can be influenced by weather and/or ice conditions. The reserve can be allocated to the domestic fishery if harvest expectations are exceeded or to the foreign fishery if the reverse situation occurs. Both of the above methods for determining allocations would be hampered by inaccurate and untimely reporting of foreign catches.

Table 1. Herring and herring roe-on-kelp harvests by domestic commercial fisheries in the eastern Bering Sea, 1964-78. 1/

Year	Herring 2/			Herring Roe-on-kelp 3/		
	Bristol Bay	Norton Sound	Total	Bristol Bay	Norton Sound	Total
1964		18	18			
1965						
1966						
1967	122		122			
1968	83		83	24		24
1969	43	2	45	5		5
1970	25	7	32	17		17
1971		18	18	24		24
1972	73	15	88	29		29
1973	46	32	78	5		5
1974	112	2	114	57		57
1975	51		51	51		51
1976		8	8	134		134
1977	2,536	10	2,546	125	trace	125
1978	7,292 4/	13	7,305	150	3	153
Total	10,383	125	10,508	621	3	624

1/ Harvests expressed in metric tons.
2/ Herring harvested predominantly for extraction of sac roe. Bristol Bay fishery initiated in 1967 with no fishery conducted in 1971 or 1976. Spring fishery begun in Norton Sound in 1964 with no operations conducted in 1965-68 or in 1975.
3/ Kelp predominantly rockweed (Fucus sp.). First Roe-on-kelp fishery began in Bristol Bay in 1968 while first harvest totaling 743 lb. occurred in Norton sound in 1977.
4/ Includes 259 metric tons from the Security Cove area.

Table 2. Herring harvests by Japan and USSR in the eastern Bering Sea, 1964-1978 1/

Year 2/ (July - June)	Trawl Fishery USSR 3/	Trawl Fishery Japan	Japanese Gillnet Fishery	Total
1964-65	-	1,362		-
1965-66	-	3,117		-
1966-67	-	2,831		-
1967-68	9,800	9,486	818	20,104
1968-69	75,379	50,857	1,949	128,185
1969-70	92,228	23,901	1,585	117,714
1970-71	60,126	24,236	4,603	88,965
1971-72	67,547	13,143	472	81,162
1972-73	39,999	346	1,878	42,223
1973-74	16,810	219	3,337	20,366
1974-75	15,039	2,663	736	18,438
1975-76	9,518	2,728 4/	2,668 4/	14,914
1976-77	18,907	1,766	- 5/	19,870
1977-78 6/	6,026	3,229	- 5/	9,255

1/ All harvests expressed in metric tons. Source of Japanese catches from INPFC documents while USSR catches furnished under provisions of US-USSR bilateral agreements.
2/ Trawl fishery normally occurs from Nov to Apr while the gillnet fishery lasted from April to June.
3/ The USSR trawl fishery began in 1961, but harvest data was not available until 1967.
4/ Preliminary.
5/ Japanese gillnet fishery closed.
6/ Preliminary.

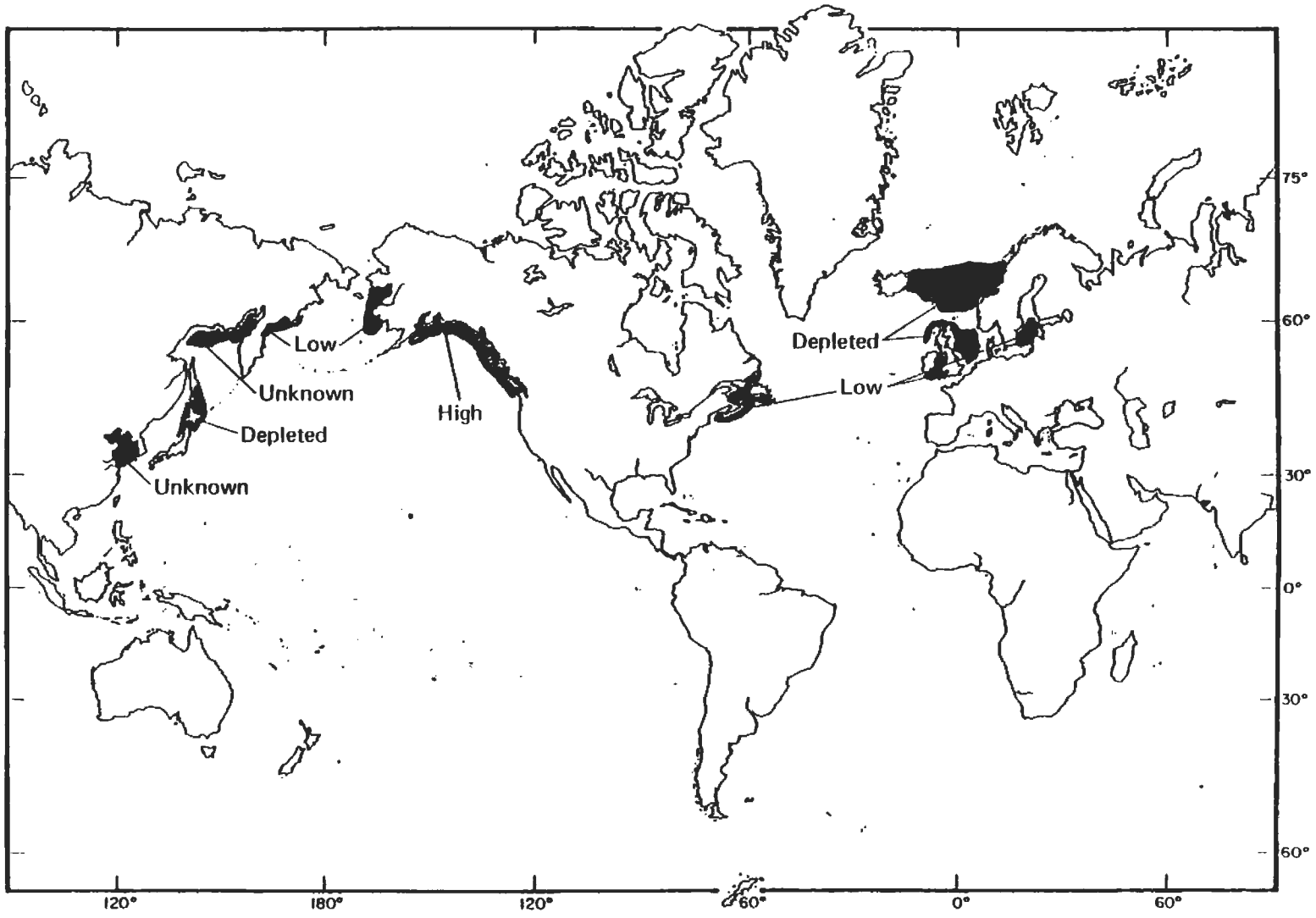

Figure 1. Distribution and general status of major world stocks of Pacific and Atlantic herring.

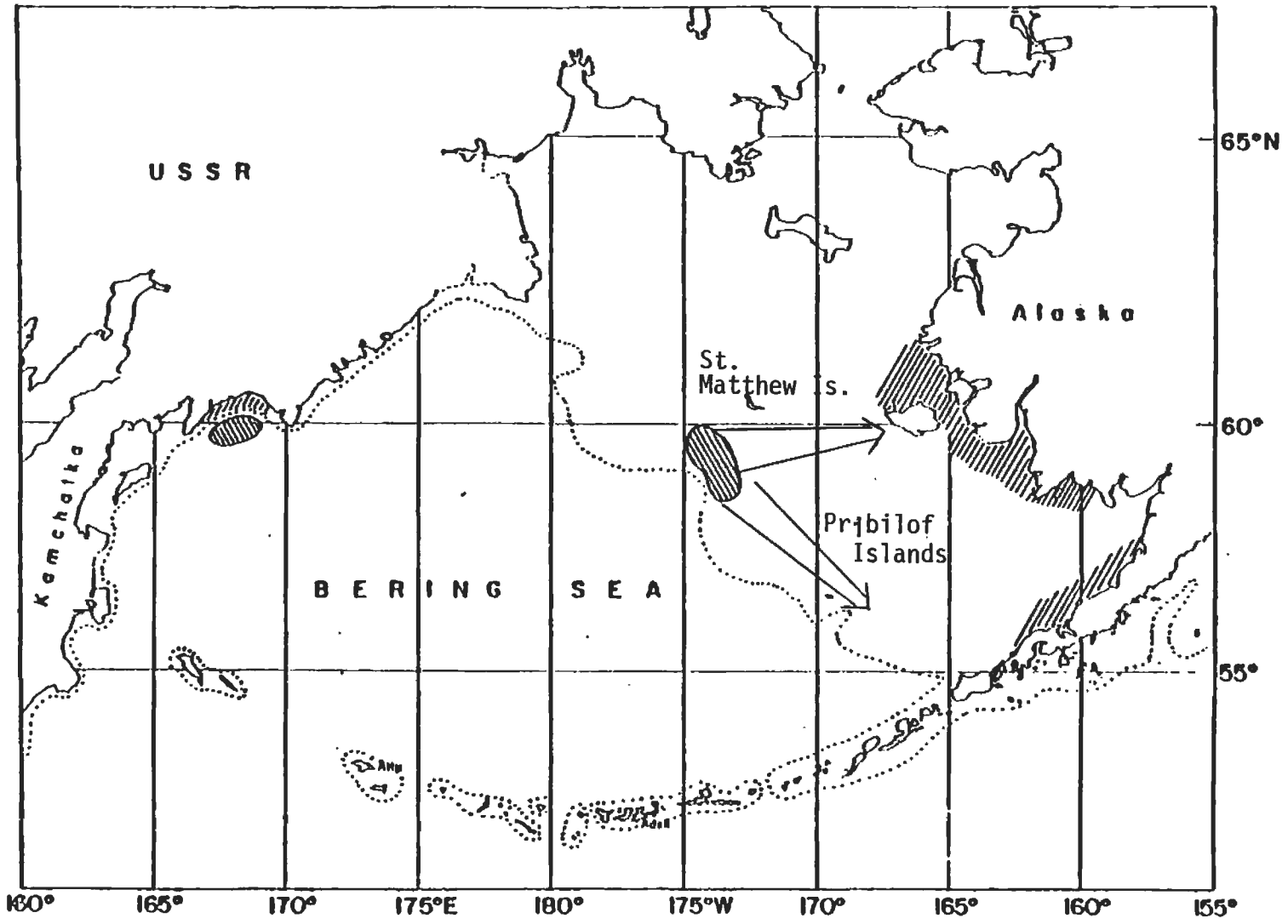

Figure 2 . Location of the spawning and winter grounds (oval areas) of main eastern and western Bering Sea herring stocks and routes of migration of eastern stocks to spawning areas.

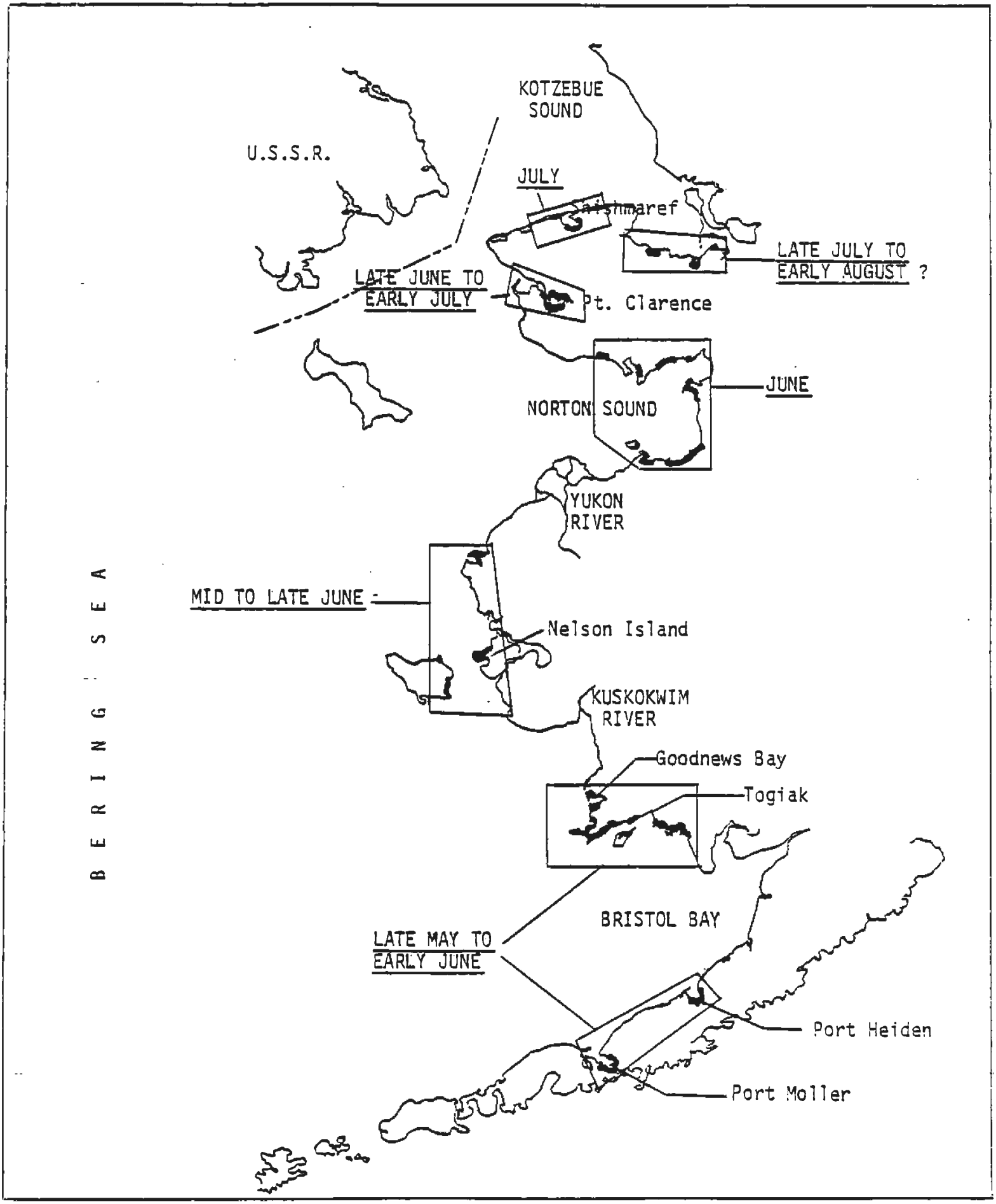

Figure 3 . Timing and distribution of Pacific herring spawning in the eastern Bering Sea.

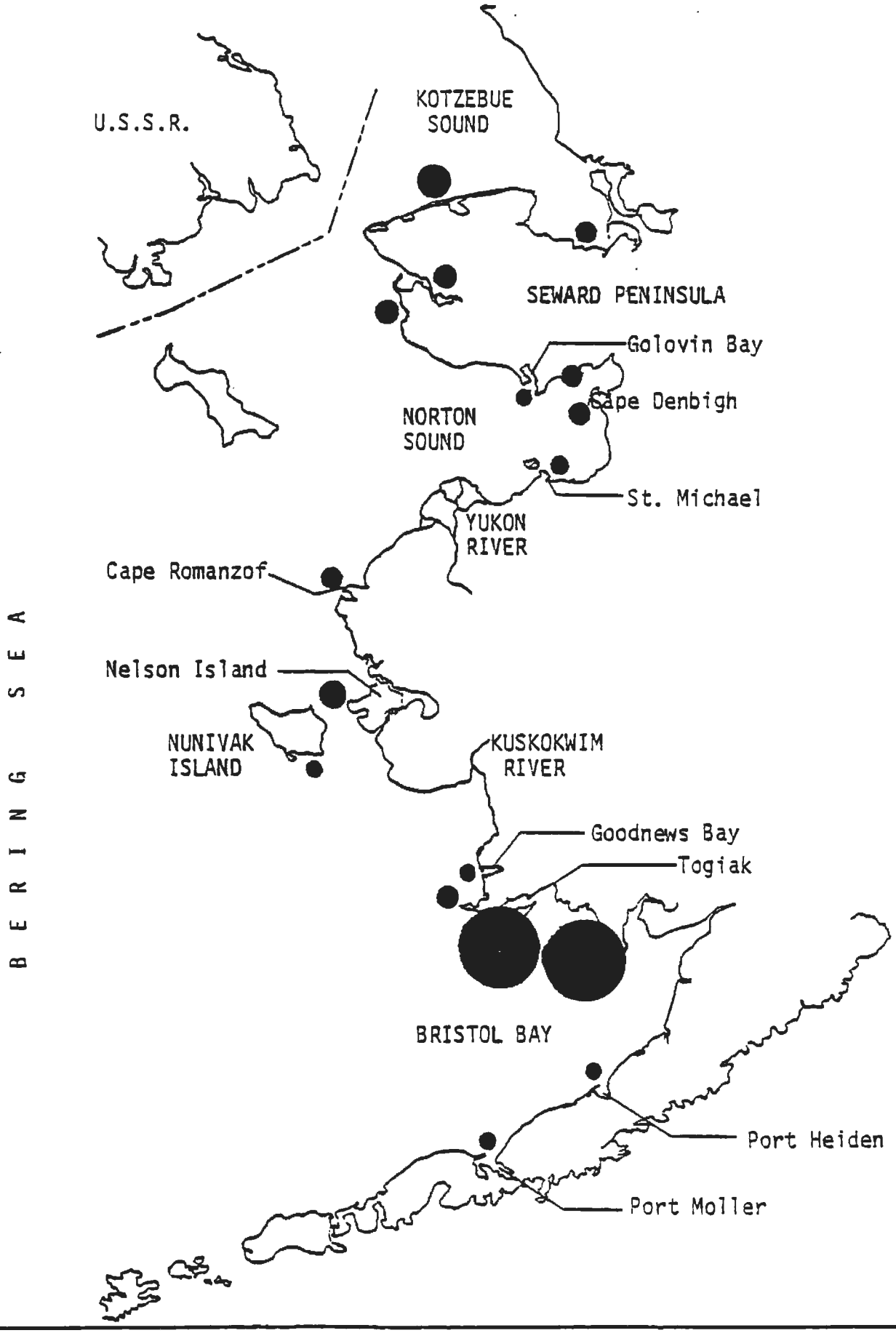

Figure 4 . Relative abundance of Pacific herring based upon peak count surface area estimates of schools observed during aerial surveys, 1976 and 1977.

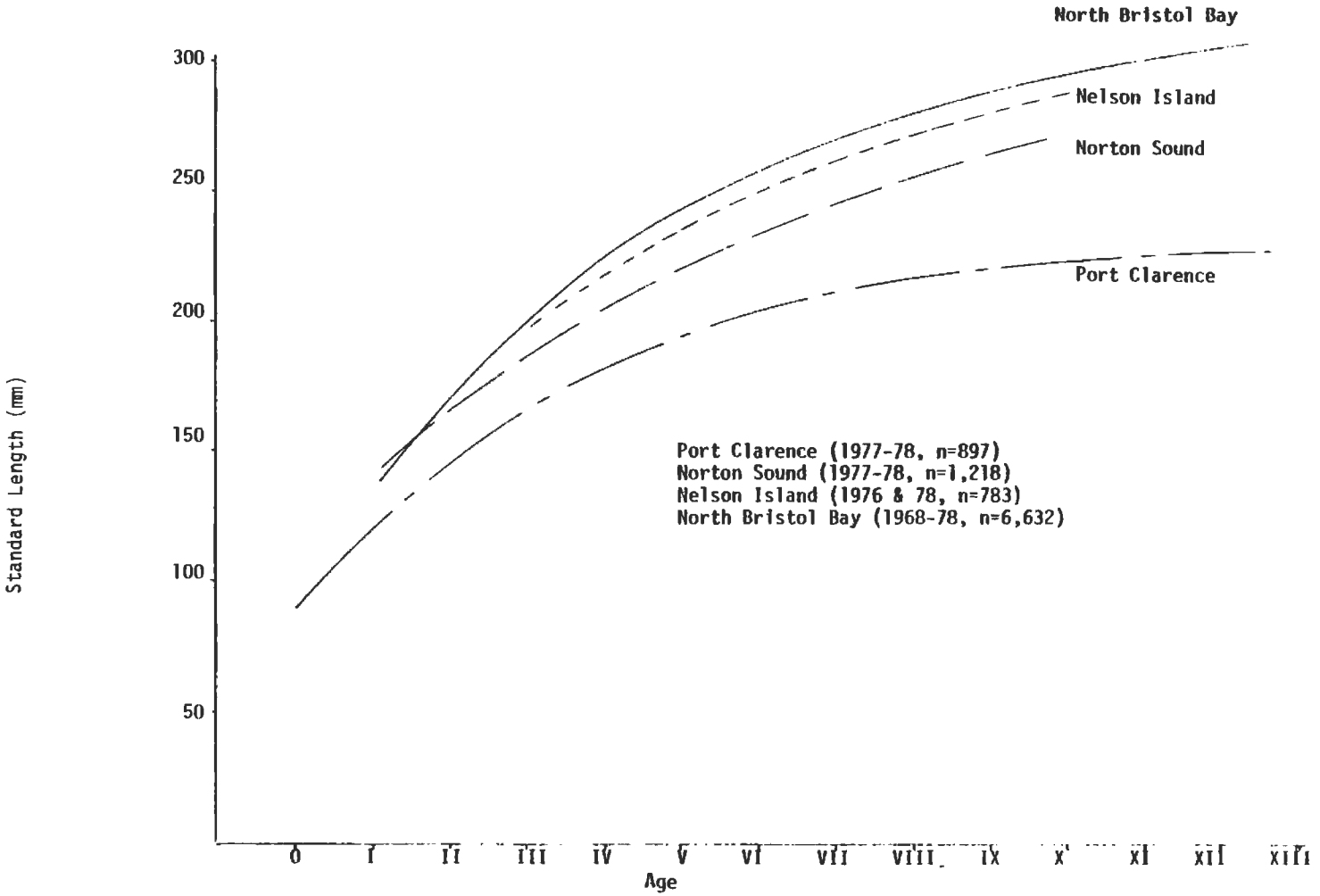

Figure 5. Size-at-age comparisons of Pacific herring from selected areas in the eastern Bering Sea. Lines are hand fitted.

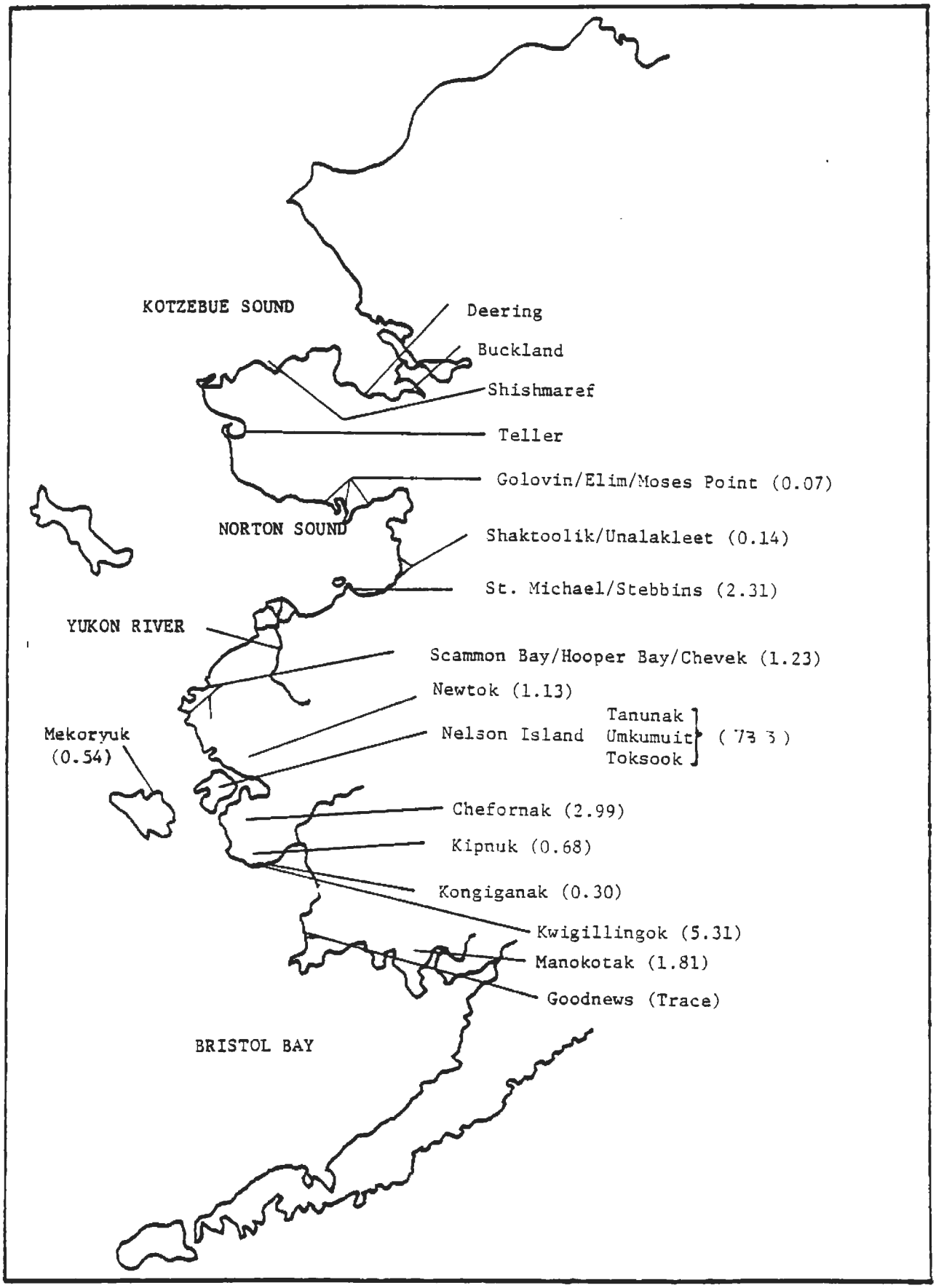

Figure 6. Average annual subsistence herring harvests (in metric tons) by eastern Bering Sea coastal villages, 1975-1978.

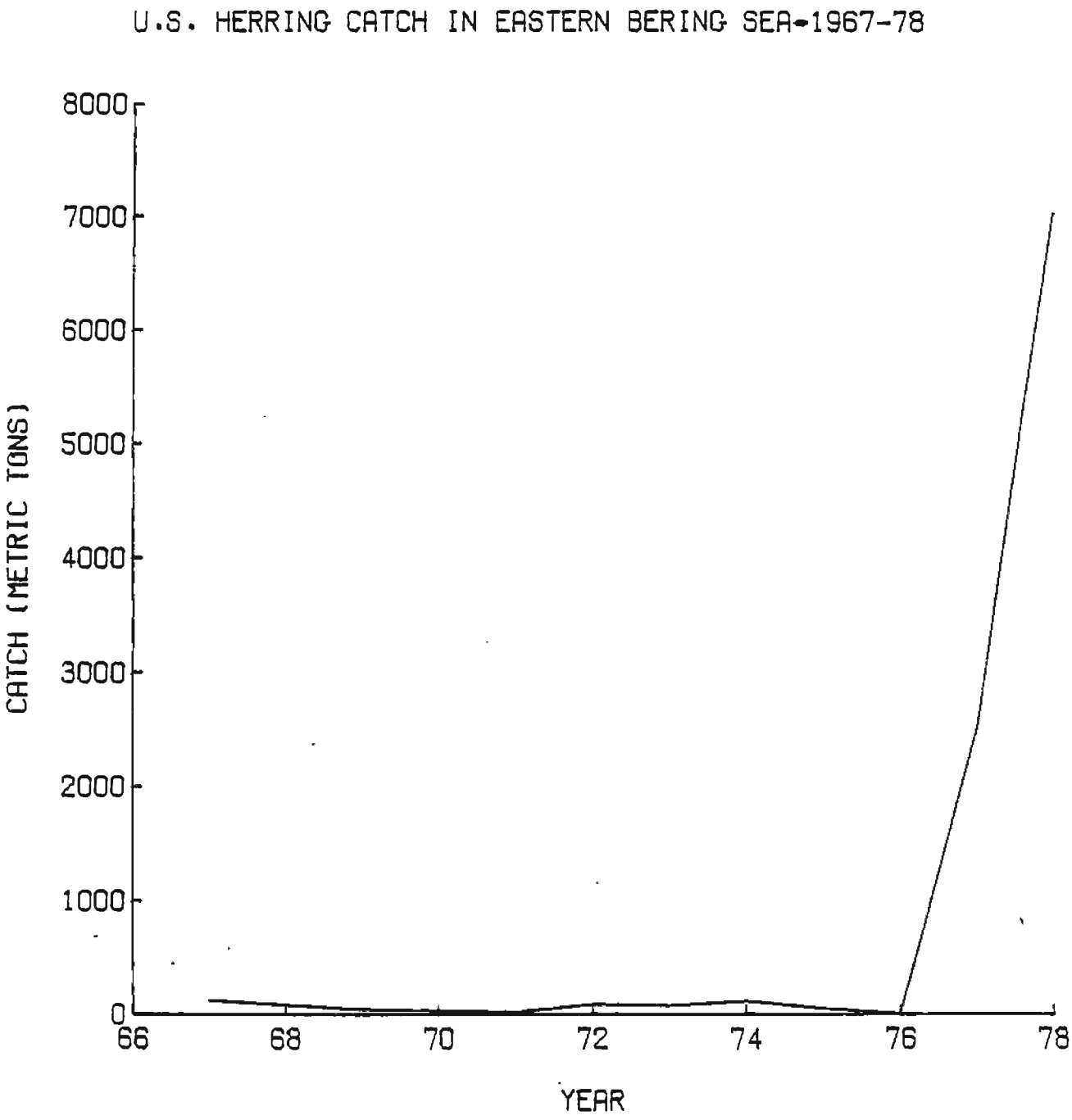

Figure 7. Herring harvests by domestic commercial fisheries in the eastern Bering Sea, 1967-1978.

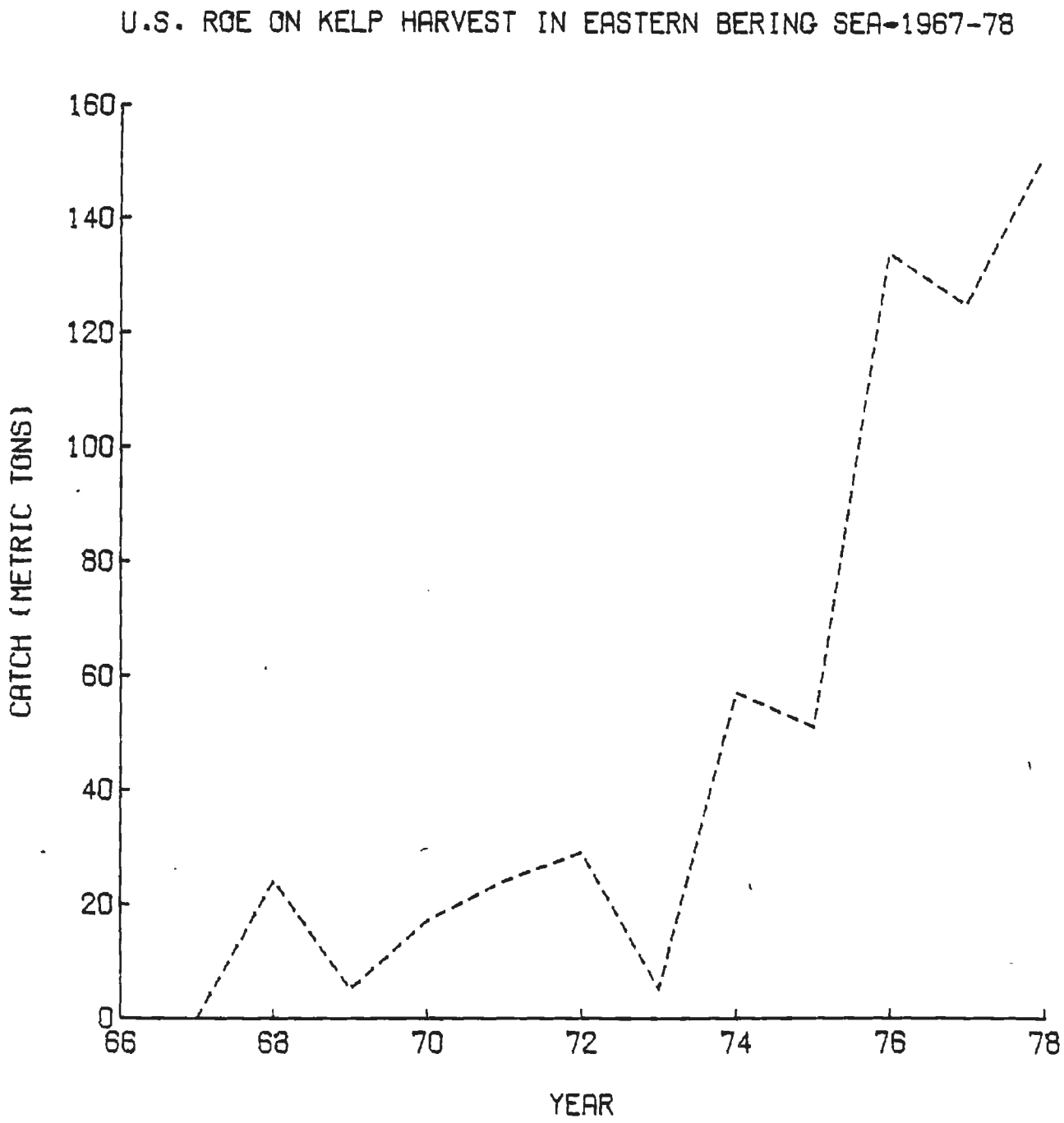

Figure 8. Herring roe-on-kelp harvests by domestic commercial fisheries in the eastern Bering Sea, 1968-1978.

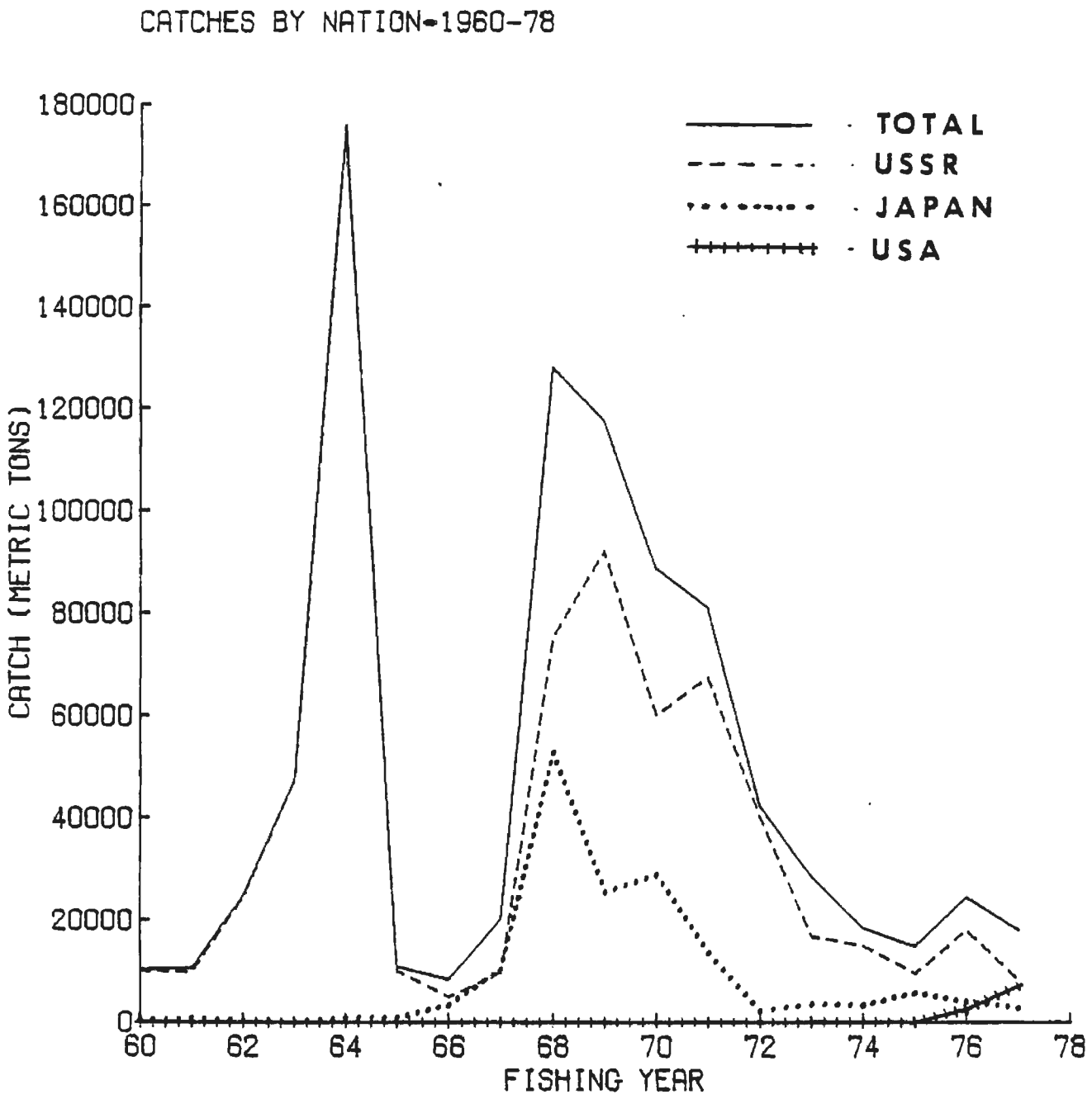

Figure 9. Herring harvests by foreign and domestic commercial fisheries in the eastern Bering Sea 1960-1978.

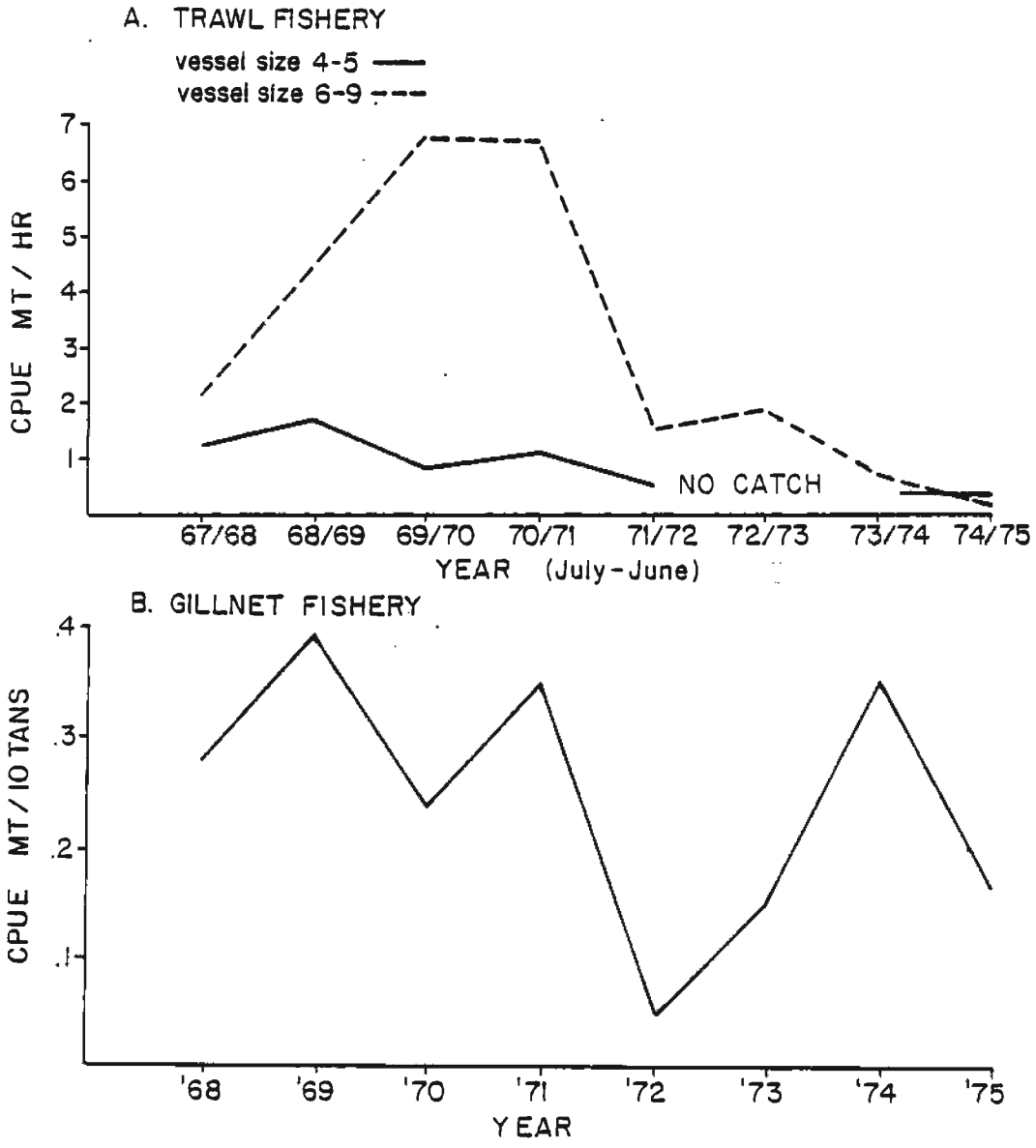

Figure 10. Herring catch per unit effort of Japanese stern trawlers and gill net vessels in the eastern Bering Sea, 1968-75.

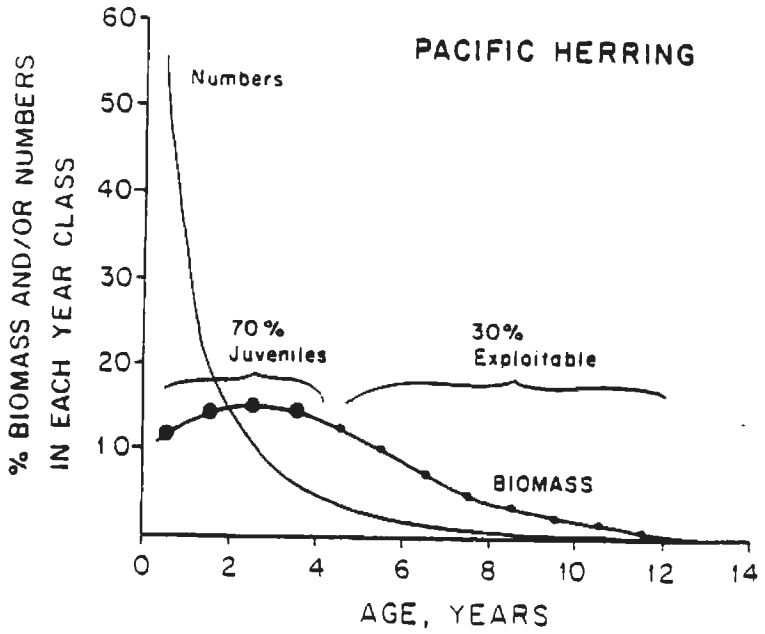

Figure 12. Distribution of numbers of fish and biomass by age class of Pacific herring.

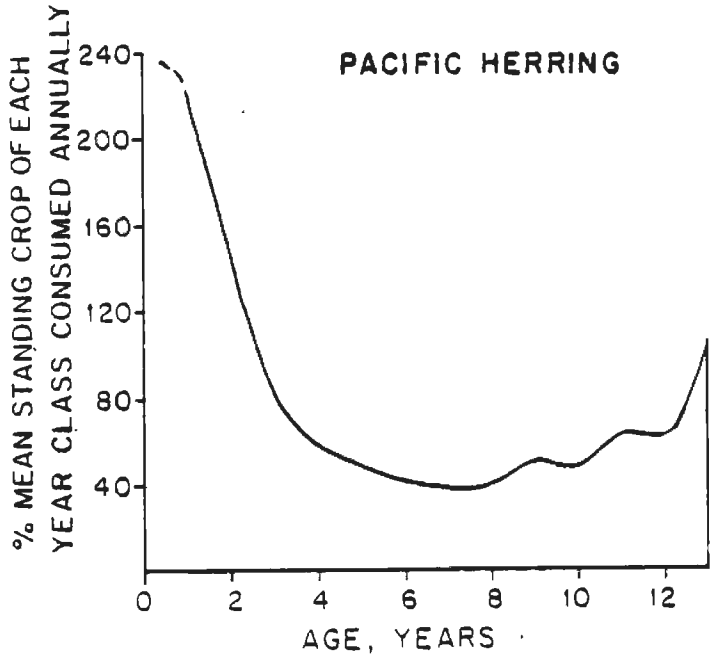

Figure 13. Total mortality by age expressed as percent loss of biomass of Pacific herring.

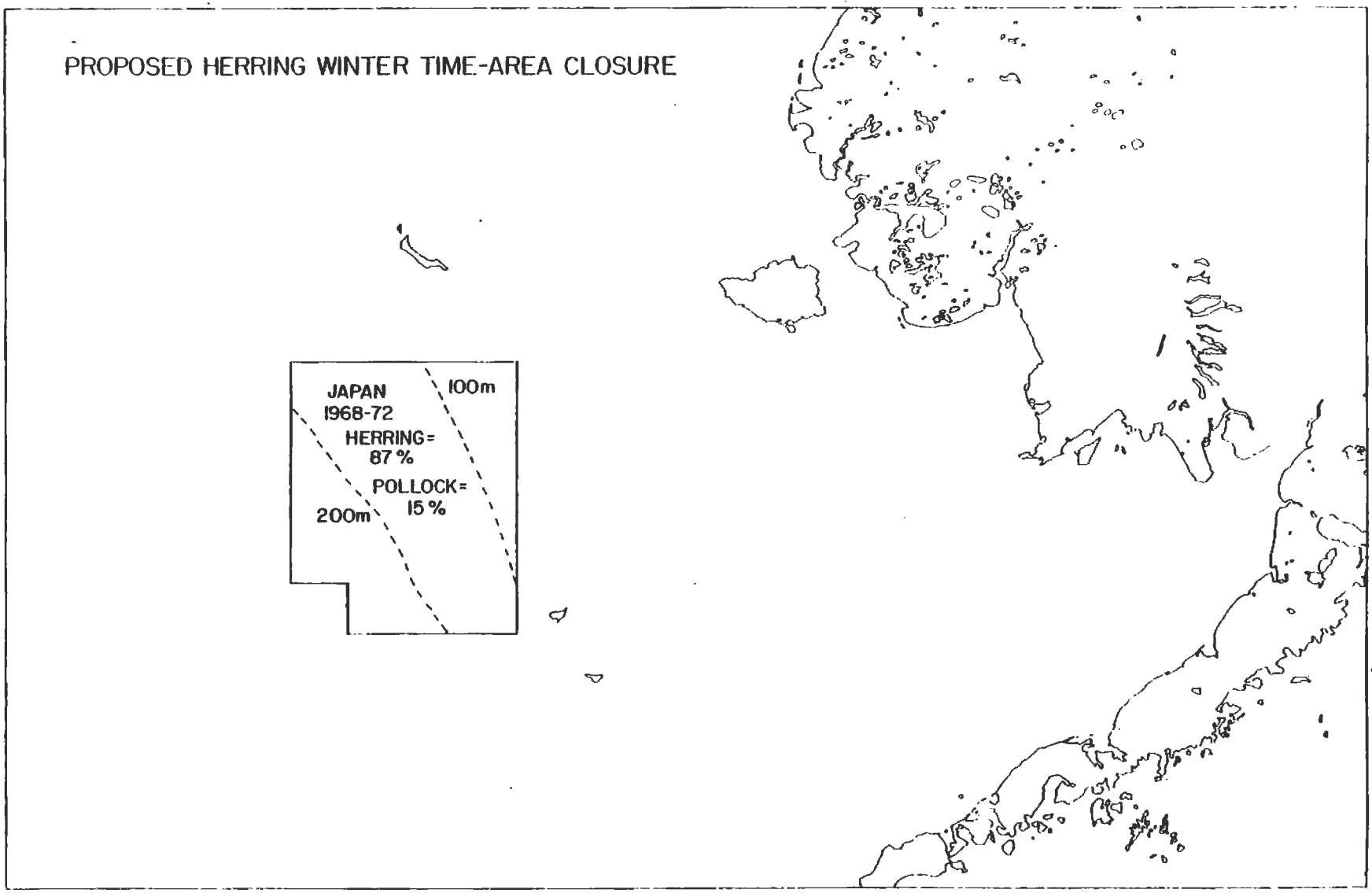

Figure 15. Location of potential winter closure area for foreign trawl fisheries for protection of eastern Bering Sea herring concentrations.